A COMPARATIVE EVALUATION OF SMEAR LAYER REMOVAL USING VARIOUS IRRIGANT ACTIVATION TECHNIQUES

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BRANCH – IV

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ENDORSEMENT BY THE H.O.D. PRINCIPAL / THE HEAD OF THE INSTITUTION

This is to certify that **Dr.ISWARYA.R.RAJU,** Post Graduate student (2014–2017) in the Department of Conservative Dentistry and Endodontics, K.S.R. Institute of Dental Science and Research, has done this dissertation titled **"A COMPARATIVE EVALUATION OF SMEAR LAYER REMOVAL USING VARIOUS IRRIGANT ACTIVATION TECHNIQUES"** under our guidance and supervision in partial fulfillment of the regulations laid down by **The Tamil Nadu Dr. M.G.R. Medical University**, Chennai – 600 032 for **M.D.S.,** (Branch – IV) **CONSERVATIVE DENTISTRY AND ENDODONTICS** degree examination.

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This is to certify that the dissertation titled **"A COMPARATIVE EVALUATION OF SMEAR LAYER REMOVAL USING VARIOUS IRRIGANT ACTIVATION TECHNIQUES"** is a bonafide research work done by **Dr.ISWARYA.R.RAJU** in partial fulfillment of the requirements for the degree of **MASTER OF DENTAL SURGERY** in the speciality of **CONSERVATIVE DENTISTRY AND ENDODONTICS**

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PLACE OF STUDY	K.S.R. Institute of Dental Science and Research
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NAME OF THE GUIDE	Dr. Sebeena Mathew
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Introduction

INTRODUCTION

The ultimate goal in cleaning and shaping of root canal system would be canal debridement and to promote apical healing.Complete removal of debris and smear layer removal is not possible alone by means of mechanical instrumentation.It is augmented by chemical sterlisation and sealing of root canal space.This prevents reinfection of root canal space.Obtaining a bacterial tight seal is an important part of root canal treatment[(1)].**Schilder** defined cleaning and shaping as the removal of all contents of the root canal system that could possibly serve as substrate for bacterial growth or as a source of periapical inflammation and the establishment of a specific cavity form that will facilitate root canal filling.

Smear layer is defined as "an amorphous, relatively smooth layer of microcrystalline debris whose featureless surface cannot be seen with the naked eye"[(2)].It is also defined as a "surface film of debris retained on dentin or other tooth surfaces like enamel or cementum after instrumentation with either rotary instruments or endodontic files".

This layer is between 1-10 μm thick, contains hydroxyapatite, denatured collagen and remnants of cariogenic bacteria. During formation of smear layer, cutting debris called smear plugs is forced invariably into dentinal tubules .Smear layer has got great influence on adhesive bond formed between the cut tooth and obturating material. It reduces dentin permeability by 86%. If this layer is not removed, it tends to weaken the bond strength between the material and the root canal wall.[(3)]

Fogel et al studied dentin morphology after various endodontic procedures under scanning electron microscope and concluded that at 2000x magnification, the smear layer consisted of two or more different layers partially superimposed with a "tree bark" configuration.[4]

The removal of smear layer prior to root canal obturation has been proposed for several reasons. The smear layer was believed to harbour bacteria and protect the bacteria inside the dentinal tubules from the antimicrobial action of root canal irrigants and medicaments[5]. Smear layer can prevent the peneteration of intracanal medicaments into the tubules and influence the adaptation of filling materials to the canal walls . Presence of smear layer causes apical leakage, prevents sealer penetration and adhesion of post to dentin by preventing hybrid layer formation.[6]

Smear layer removal or retention is a controversy that fluctuates with the various modalities of restorative dentistry and endodontics.

Irrigation forms an integral part of the chemo-mechanical preparation of the root canal system. An irrigant serves to flush out debris from within the instrumented root canals, dissolve the organic tissue remnants, disinfect the root canal space and provide lubrication during instrumentation [7].

Numerous chemical agents have been tested for their suitability as a root canal irrigant. Sodium hypochlorite (NaOCl) is the gold standard agent for irrigation in endodontics, although optimum working concentration has not been universally agreed. Quaternary ammonium compounds have limited antimicrobial effects and do not provide an ideal fluid for irrigation. Ethylene diamine

tetra acetic acid (EDTA) dissolves mineralized but not soft tissues by chelation. It may be a useful adjunct to NaOCl in removing the smear layer after root canal instrumentation [8].

In a quest to minimize the smear layer, several irrigants and irrigant activation techniques were accomplished. There by it effects the scrupulous sealing of root canal space. Effective smear layer removal has been accomplished using chemical means and methods such as ultrasound, laser and hydrodynamic disinfection for its disruption. But there is no evidence to suggest which material or technique of irrigation is best and reliable .

The purpose of this study is to evaluate the removal of smear layer after treating the root canal with sodium hypochlorite and EDTA, then activating the final irrigant with three different irrigant activation techniques ,i.e, manual agitation, laser and ultrasonic technique.

Aims and Objective

AIM

To evaluate the efficacy in smear layer removal using a combination of 3% sodium hypochlorite (NaOCl) and 17 % Ethylene diamine tetra acetic acid (EDTA) along with three final irrigant activation techniques like manual agitation, ultrasonic agitation and laser agitation

OBJECTIVES

1.The hypothesis of this study is that the final irrigant activation techniques like manual agitation, laser activation and ultrasonic activation improves the smear layer removal.

2.To evaluate the efficacy of smear layer removal among the three irrigant activation techniques.

Review Of Literature

REVIEW OF LITERATURE

Researchers became aware of endodontic smear layer by 1975. When reaming and filing is done in the root canal, a smear layer similar to that formed on operative procedures of tooth preparations , are produced on the dentinal walls. This has been demonstrated in many studies conducted using SEM by **Banker (1975), Mc Comb, Smith (1976), Lester** and **Boyde (1977), Goldmann (1982), Eick(1970)** who referred to it as the "smeared layer".

Mader (1984) described the smear layer material in two parts: First, superficial smear layer ,which is that adheres loosely to the underlying dentin and second, the smear material is that which is packed into dentinal tubules called smear plugs.The extension of this packed material into dentinal tubules was calculated as extending up to 40um. [(9)]

The components of the smear layer have been listed by **Schulein TM (1985)** based on his studies as it contains both organic and inorganic components. The organic components may consist of heat coagulated proteins (gelatin formed by the deterioration of collagen heated by cutting temperatures), necrotic or viable pulp tissue, odontoblastic processes, saliva, blood cells and microorganisms and inorganic portion of the smear layer contains minerals from the dentinal structures and some non specific inorganic contaminants.**(10)**

According to **Orstavik D and Haapasalo M (1990).** The presence of the smear layer delayed the action of disinfectants on bacteria harboured in the dentinal tubules.**(11)**

According to **Pashely DH (1984)** The smear layer when present serves as a receptacle for microbial irritants .[12]

In **(1985) Pashley** suggested that if canals are inadequately disinfected or bacterial contamination occurred after root canal preparation,presence of smear layer might stop bacterial invasion into tubules.[13]

Love RM (1996) concluded that smear layer serves as a barrier to prevent bacterial migration into the tubules.[14]

Goldman in 1979 demonstrated that the smear layer was tenacious when irrigated with conventional needle as well as the perforated needle.

Goldman in 1980, tested various solutions individually and in combinations.He concluded that the chelating agent REDTA removed the debris satisfactorly,even when used singularly.

In 1982 Goldmann observed that the smear layer removal was effective when using EDTA and NaOCl as a final flush. He also recommend alternate use of sodium hypochlorite and EDTA.[15]

Sodium hypochlorite removes organic material and also the collagenous matrix of dentin whereas EDTA removes the mineralized dentin, thereby exposing more collagen.[16]

Cleaning of the root canal system using mechanical instrumentation often is ineffective due to extremely complex root canal morphology, as illustrated by **Stock**[16]**.**Proper irrigation of the root canal system during endodontic therapy is vital for successful treatment. Many teeth have numerous accessory canals and fissures that cannot be negotiated by files. For this reason many mechanically well prepared main canals still have irregularities that are never contacted by endodontics instrumentation. Chemical debridement is performed in inaccessable areas like fins or other irregularities that might be missed by instrumentation.[17]

Torabinejad M (2002) reported the presence or absence, of a smear layer may play an important role in the adhesiveness of some sealers to the root canal walls. Studies have shown that when the smear layer was removed , AH26 sealer showed increase in adhesive strength and resistance to microleakage. [18]

Torabinejad M (2003) Used Tetracycline's along with acids and detergents (MTAD) which showed significantly cleaner canals than those treated with routine EDTA. The MTAD was less destructive to the tooth structure compared to the EDTA when used as a final irrigant. MTAD does not significantly change the structure of the dentinal tubules when used in conjunction with NaOCl as a root canal irrigant.[19]

Evren OK (2015) [20] concluded that chlorhexidine is useful as an alternative endodontic irrigant. Its excellent antimicrobial properties indicate it could be a useful substitute in patients who are allergic to sodium hypochlorite [13]. In addition, it also could be used in teeth with very patent apices. Irrigating such teeth with sodium hypochlorite might allow escape of the sodium hypochlorite through the apex and induce excessive periapical inflammation. In similar circumstances, chlorhexidine would be innocuous.[21]

Kailash (2016) compared the smear layer removal efficacy of 17 % EDTA ,7% maleic acid and 2% chlorhexidine using scanning electron microscope. 17 %EDTA efficiently removed smear where as smear layer removal was very minimal using chlorhexidine and maleic acid.[22]

Moorer & Wesselink (1982) found that increasing the temperature of NaOCl resulted in removal of smear layer but was ineffective in removing the smear layer from instrumented canals. [23]

Morgan & Baumgartner (1999) showed that the quantity of smear layer removed by a material is related to its pH and the time of exposure. [24]

Menezes AC (2003) concluded in his study that use of 17% EDTA enhanced removal of smear layer from the root canals. [25]

Michael S (2000) compared three solutions of EDTA - 15% concentration of the alkaline salt, a 15% concentration of the acid salt, and a 25% concentration of the alkaline salt and said that none of the EDTA solutions by themselves were effective at completely removing the smear layer at any level.[26]

Cameron (1988) This study was based on observations made during the recovery of root canal filling models. When a tooth that had been prepared to meet clinical standards was root filled and then split, the root canal sealer adhered to the gutta-percha. If an instrumented tooth was subjected to 3% NaOCI in an ultrasonic bath before root filling and splitting, then the root canal sealer showed equal adhesion to gutta-percha or the root canal wall. The smear layer

appeared to be serving as a "release layer," as is used in fiberglass moulding, and to be preventing the sealer from adhering to the canal wall. This effect could have clinical significance because the setting shrinkage of the sealer could pull the sealer away from the canal wall, whereas a space between the gutta-percha and sealer would be preferable. A smear-free wall would be more receptive to adhesive or chemically bonded sealers .[27]

Goldmann(1981) later found that the perforated needle produced a much cleaner canal, with fewer dentin chips, and much less debris than did the conventional needle.[28]

Takeda FH (1999) compared three types of endodontic irrigants and two types of lasers for smear layer removal .He concluded that irrigation with 17% EDTA, 6% phosphoric acid and 10 % citric acid did not remove all the smear layer from the root canal system. In addition, these acidic solutions demineralized the intertubular dentin around tubular openings, which became enlarged. The CO_2 laser was useful in removing and melting the smear layer on the instrumented root-canal walls and the Er: YAG laser was the most effective in removing the smear layer from the root canal wall. The observable effects of laser irradiation on the dentin of prepared canal walls ranged from no effects of disruption of the smear layer to an actual melting and recrystallization of the dentin into a non-porous, glazed surface containing needle like crystal formations in a non-porous dentin.[29]

Investigators have reported that the effectiveness of lasers depends on many factors, including the power level, the duration of exposure, the absorption of light in the tissue, the geometry of the root canal, and the tip-to-target distance. Although lasers showed removal of smear layer, the main difficulty of the smear removal with laser is that it, continues to be difficult to access the small canal spaces with relatively large probes that are available for delivery of the laser beam.[30]

Goldman (1981) [28] and **Yamada (1983)** [31], suggested using 10 ml of 17% EDTA and 10 ml of 5.25% NaOCl in volume for removing the smear layer from the root canal, while **Goldman (1981)** [8] suggested 90ml of 17 % EDTA for removal of smear layer, **Berg (1984)** [18] reported that 2 ml of 15% EDTA and 2ml of 3% NaOCl was sufficient in removing smear layer.

Gettlemen (1991)[32] conducted a study using AH26, Sultan, and Sealapex sealers.He observed that AH26 was the strongest sealer and Sealapex was the weakest sealer . The only difference with regard to the presence or absence of the smear layer was found with AH26, which had a stronger bond when the smear layer was removed.

Crumpton (2005) evaluated and concluded that efficient removal of the smear layer was accomplished with a final rinse of 1 ml of 17% EDTA for 1 min, followed by 3 ml of 5.25% NaOCl [33]

Gu XH (2009) observed in his study that EDTA performed significantly better than NaOCl in smear layer removal and dentinal tubule opening. Additional ultrasonic irrigation of EDTA improved smear layer removal significantly.[34]

Qian zheng (2016) reported that the removal of smear layer paves way for the dental pulp stem cells migration from root canal walls ,which was validated by growth factor array.[35]

Aline Martins (2014) used ultrasonics as an adjuvant in smear removal along with NaOCl ,CHX and saline. These irrigants were activated 3 times for 20 seconds. He concluded that

passive ultrasonic irrigation showed efficient removal of smear layer. Samples that were subjected to final irrigation protocols with passive ultrasonic irrigation (PUI) were more effective in removing debris from simulated canal irregularities in the apical third than the samples that did not use PUI.[36]

Laila gonzales (2015) reported Passive Ultrasonic Irrigation and the Endovac system were equally efficient in the removal of hard tissue debris.[37]

Prasenna Neelakantan (2015) did a fourier transform infrared spectroscopic study and push out bond strength analysis and concluded that irrigation protocol differentially affects the bond strength of sealers.[38]

Prasenna Neelakantan (2016) histologically assessed debridement of root canal isthumus by different irrigant agitation techniques in molar teeth and reported passive ultrasonic activation and manual dynamic activation were less effective than continuous warm activated irrigation and evacuation system.[39]

Grasiele Assis (2015) compared laser ,ultrasound ,protaper and canal brushes on smear layer removal. None of the agitation methods completely removed smear layer. Agitation of sodium hypochlorite improved the smear layer removal in apical thirds of the canal .Ultrasonics were better when compared to other activation techniques.[40]

According to **Tamer (2015)**Passive ultrasonic irrigation by using 1% NaOCl and ultrasonic tip placed within 1mm of the apical foramen did not show higher efficacy in smear layer removal compared with conventional irrigation. [(41)]

Arslan, **Dilara (2016)** compared the removal of smear layer using PIPS, Er:YAG Laser and Endoactivator, as an adjuvant to Qmix .The Endo activator and Er:YAG laser enhanced the smear layer removal ability of QMix in the apical thirds of the canals. QMix removed more smear layer in the coronal thirds when activated with the PIPS technique.[(42)]

Methodology

MATERIALS AND METHODS

Armamentarium used in the study:

- Extracted teeth
- Endodontic files size 8,10,15,20 size (Denstply Maillefer, R110566700)
- X smart plus (Dentsply mallefer)
- Protaper Rotary files (Dentsply)
- Sodium hypochlorite 5% (VIP Vensons, India, 17160)
- Normal saline (nirlife NIRMA LIMITED, IF30384)
- Ethylene diamine tetra acetatic acid (EDTA) 17 % (Prevest Dentpro)
- Guttapercha cones(Dentsply)
- Diode Laser (Picasso 970nm)
- Ultrasonic device (SETLEC,Newtron P5X5)
- Endosonic file (15 #)
- Diamond disc and mandrel
- Chisel
- Scanning electron microscope (Zeiss sigma V)
- Disposible syringe (Dispovan) 24 Guage

SOURCE OF DATA

This study was undertaken to investigate the efficiency of the removal of smear layer using three irrigant activation techniques.Single rooted teeth extracted for periodontal reasons and caries had been collected from Government medical college,Vellore.The study was conducted in the Department of Conservative Dentistry and Endodontics, K.S.R Institute of Dental Science and Research ,Tiruchengode and SEM analysis had been done in SITRA,Coimbatore .

CRITERIA FOR SELECTION OF TEETH

60 human maxillary incisor teeth were collected from Government medical college,Vellore with the approval of the Ethical Committee.

Teeth were stored in a thymol solution until use. Rinsed with saline .Gross debris was removed from the root surfaces with a 10 minute soak in 6 % NaOCl. The root surface and apical portion of each tooth were examined for the absence of fractures and resorption and the presence of a mature apex.

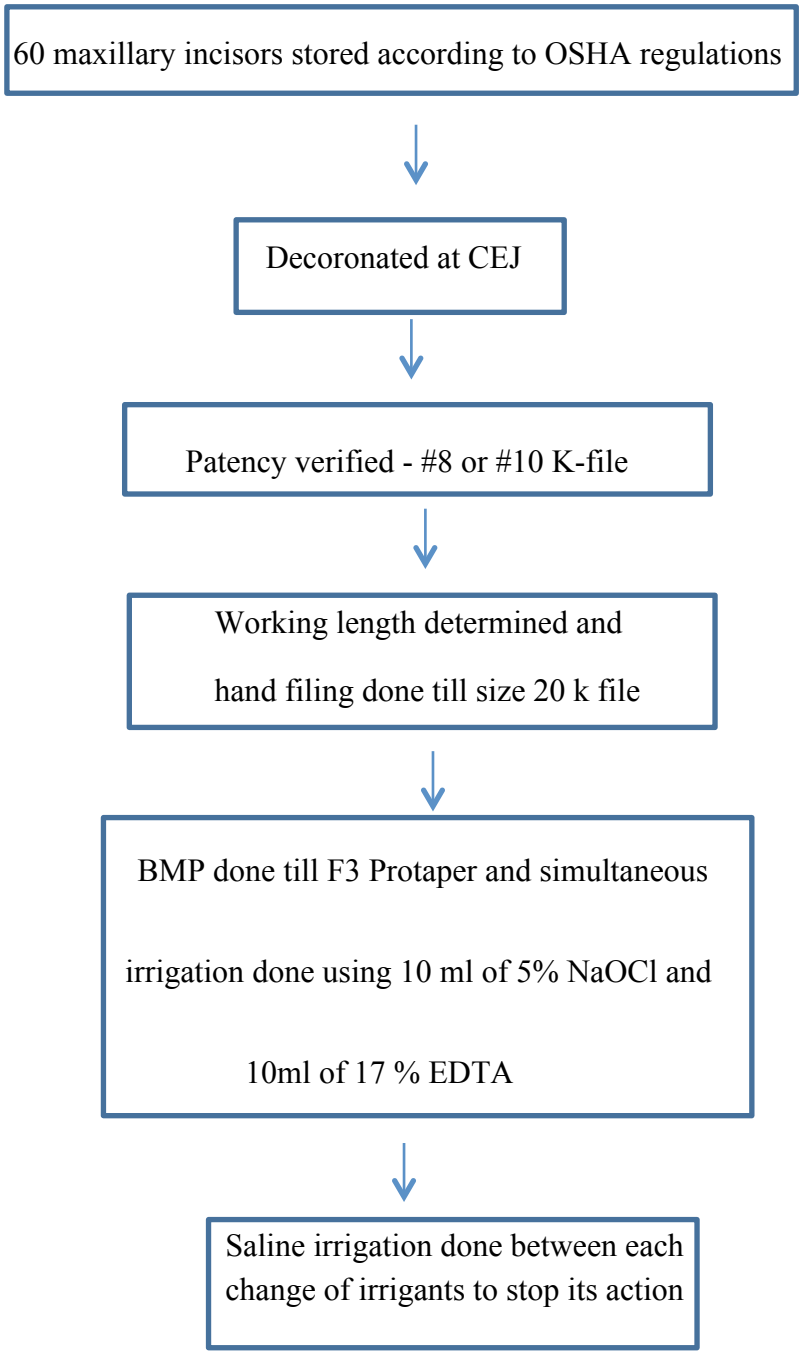
INCLUSION CRITERIA

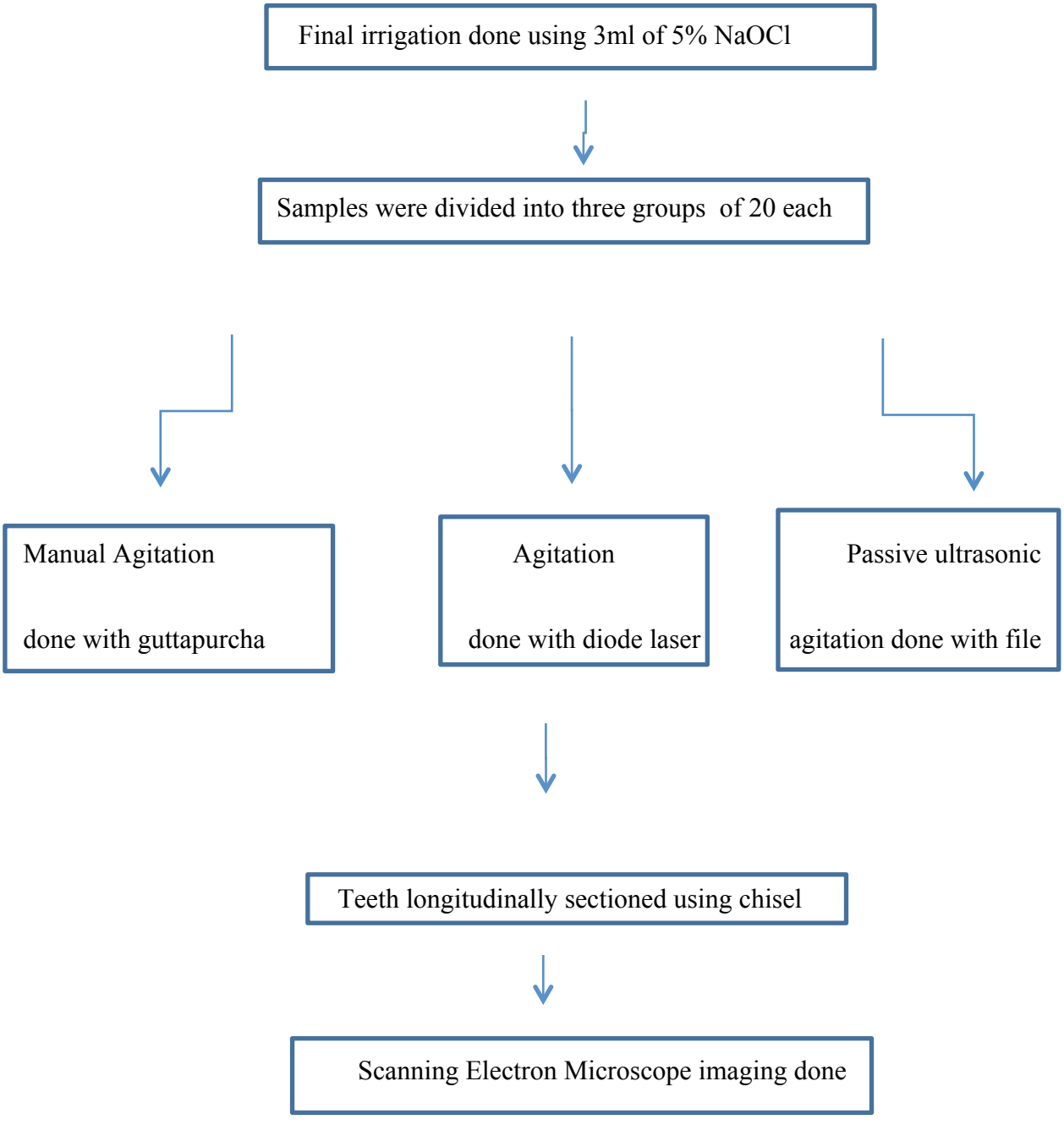
- Single rooted maxillary incisors
- Teeth with single root canal
- Teeth with preferably round canal

EXCLUSION CRITERIA

- Multi radicular teeth
- Teeth with anomalies
- Oval or ribbon canal teeth
- Curved rooted teeth

FLOWCHART OF METHODOLOGY




Final irrigation done using 3ml of 5% NaOCl
Samples were divided into three groups of 20 each
Manual Agitation
done with guttapurcha
Agitation
done with diode laser
Passive ultrasonic
agitation done with file
Teeth longitudinally sectioned using chisel
Scanning Electron Microscope imaging done

Scoring was done based on Guttman rating system. Data was statistically analysed using Kruskal wallis and Mann whitney test

SPECIMEN PREPARATION

ROOT CANAL PREPARATION

The crown of each tooth was sectioned at the cemento-enamel junction with a diamond disk to gain unrestricted access to the root canal system and to obtain a constant reference point for all measurements. A #8 or #10 K-file was inserted into the root canals until the tip of the instrument was just visible at the major apical foramen to verify patency of the canal space and the apical foramen. The stopper was adjusted to correspond to the flat reference surface. Apices of the roots were sealed with sticky wax to simulate the clinical conditions.

The root canal instrumentation was done till size 20. Coronal third was preflared using the Sx files of ProTaper rotary (Denstply Maillefer) then followed by S1,S2,F1,F2,F3 instruments. Each canal was irrigated with total 10mL of 5% sodium hypochlorite (NaOCl) solution followed by 10 ml of 17 %EDTA after each change of file.Saline was used to flush after the use of each chemical to terminate its action.Patency was constantly checked.

All the specimens were divided into three groups of 20 each .Final irrigation was done using 3ml of 5% NaOCl .

GROUPING OF SAMPLES

Group A- Manual agitation was done using guttapercha of smaller size for 1minute.

Group B -Laser agitation was done with a 200μm fiber optic tip .It was introduced into the root canal up to the working length . Diode laser of 970 nm, 1.5watts power , pulsed mode was used.The Laser was activated and withdrawn gently from the root canal to the coronal region with a helicoid movement and reintroduced to the apex for a total laser irradiation cycle of 2 minutes.

Group C -Passive Ultrasonic activation was done using an endosonic file (size 15,21mm) for 2 minutes.

The root canals were finally flushed using 5 ml of saline to terminate the action of irrigating solutions. Specimens were dried and longitudinally cut for Scanning electron microscope examination.

SECTIONING AND IMAGE ANALYSIS

The specimens were grooved along the buccal and lingual planes using a diamond disc at low speed.Then the roots were split into two halves with a chisel and a mallet.One half of each root was selected and prepared for SEM analysis.The samples were progressively dehydrated using ethanol(70%,80%,90% and absolute alchohol) for 24 hours at each concentration.After dessication samples were gold sputtered in a vaccum chamber. The dentinal wall of the root canals were examined at the coronal,middle and apical thirds at a magnification of 1000x, for absence and presence of open dentinal tubules.

180 photographs were analysed individually for open dentinal tubules by two observers in a blind scoring manner and the scoring was done based on the Guttman rating system[(Appendix1)].The mean score of two observers were calculated.The statistical analysis for evaluating the smear layer removal between group A,B,C at coronal,middle and apical third was done using Kruskal Wallis test subsequently followed by Mann Whitney test .The scores of smear layer removal at coronal,middle and apical third of the individual groups were analysed using Kruskal Wallis test. The level of significance was set at $p=0.05$.

ARMAMENTARIUM USED

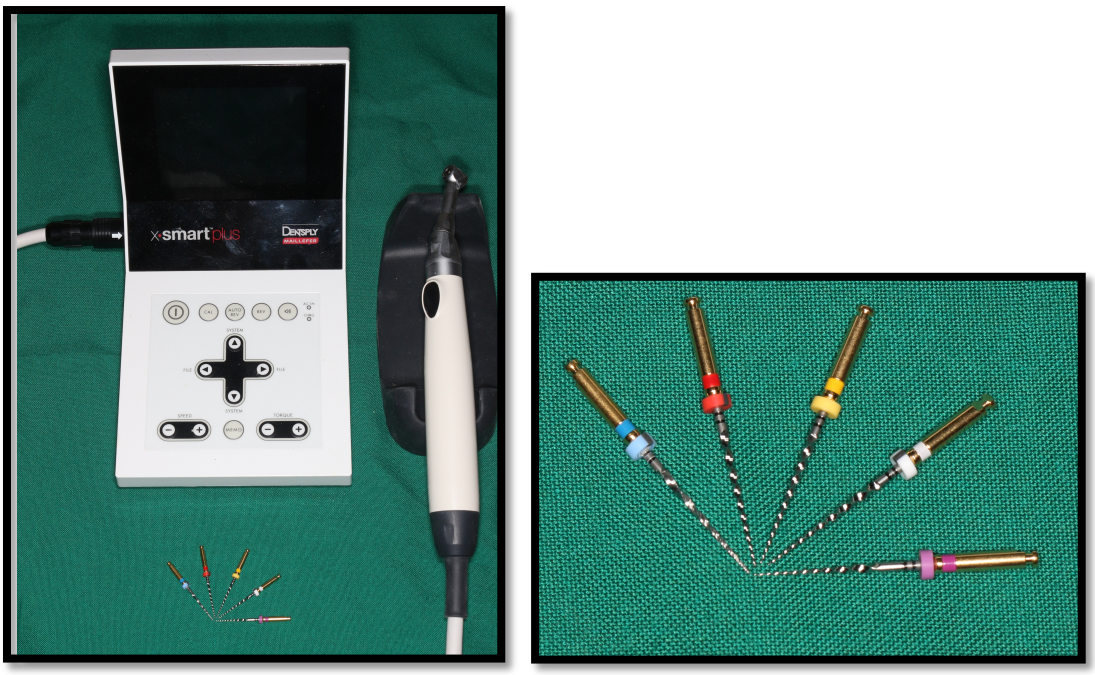


Fig :1 X Smart plus (Dentsply) and Protaper files S1,S2,F1,F2,F3.

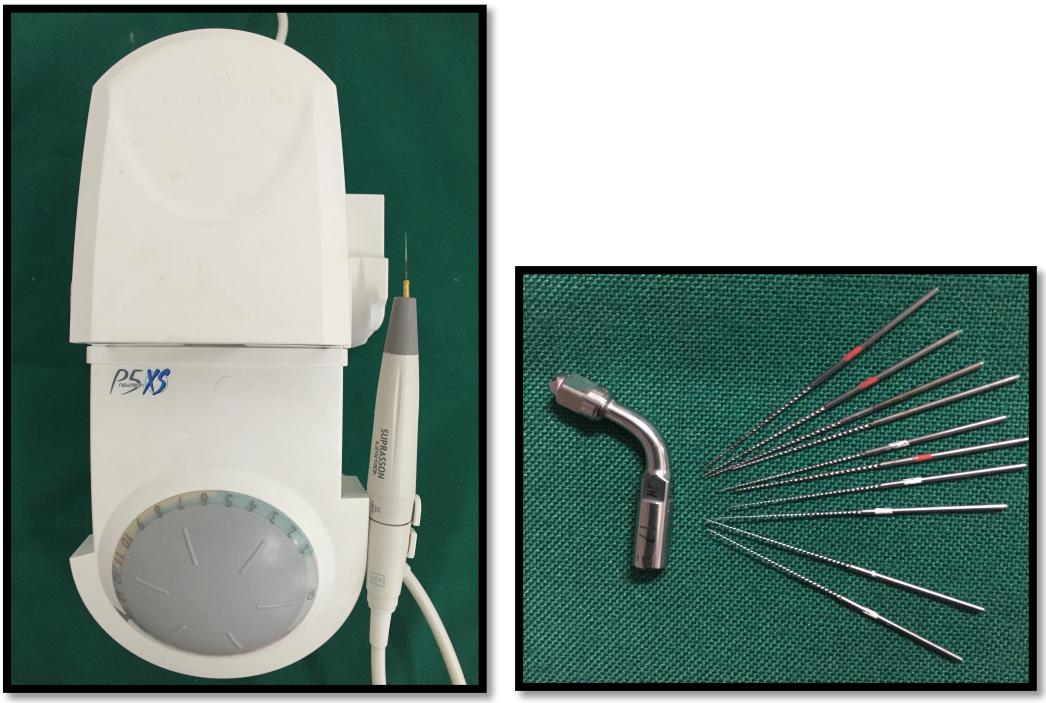


Fig :2 SETLEC ultrasonic device with endosonic files

Fig 3 :Irrigating Solutions Hypochlorite 5% , EDTA 17%,Saline (0.9% Sodium chloride W/V),Guttapercha cones used for manual dynamic agitation.

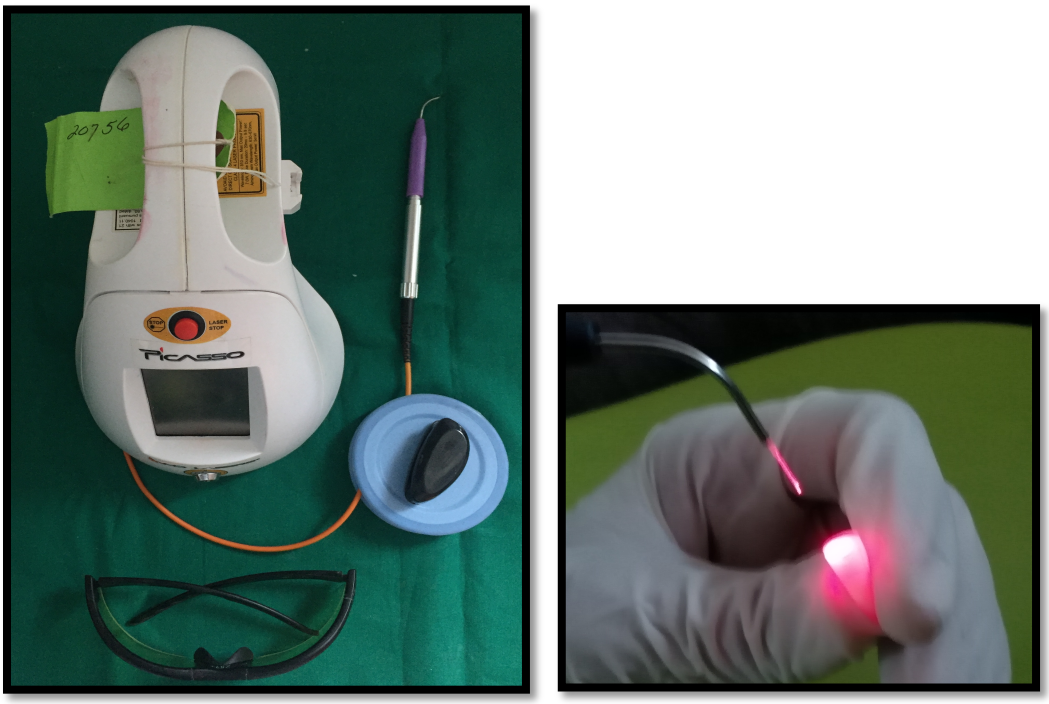


Fig 4 :Diode laser system and laser agitation

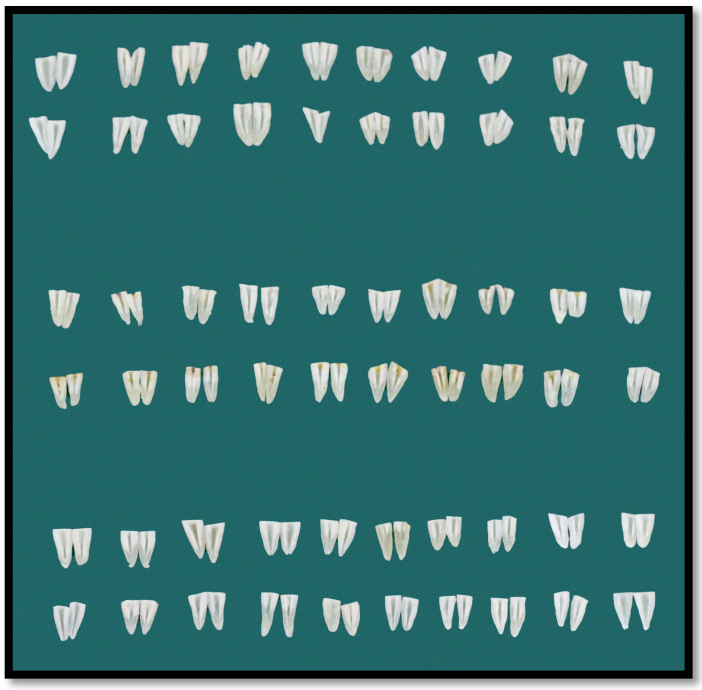


Fig 5 Showing samples cut longitudinaly after treatment

Fig 6 : stub on to which samples are to be mounted using carbon tape

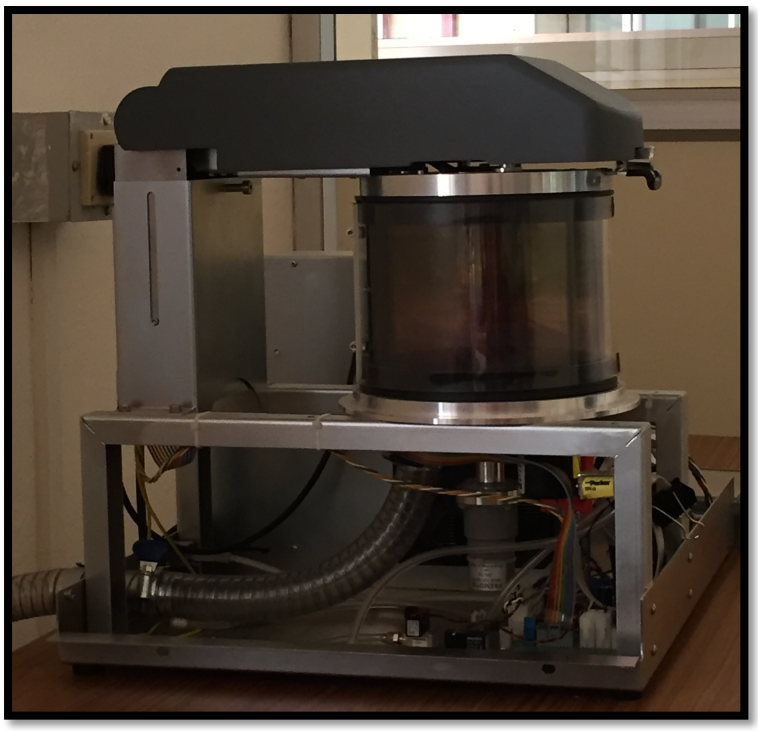


Fig 7 : Vaccum chamber for gold sputtering

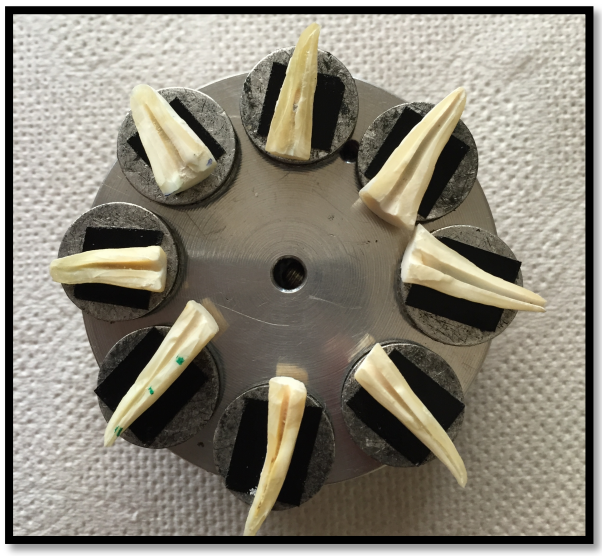


Fig 8 : Gold sputtered samples placed in carrier for Scanning electron microscope examination

Fig 9 : Scanning Electron Microscope Zeiss Sigma V used for analysis

Results

Table 1: SCORES OF SMEAR LAYER REMOVAL AFTER MANUAL ACTIVATION OF FINAL IRRIGANT BY GUTTMAN RATING SYSTEM IN GROUP A (Manual dynamic agitation)

SAMPLE NO	CORONAL		MIDDLE		APICAL	
	Observer1	Observer2	Observer1	Observer2	Observer1	Observer2
1	1	2	2	3	4	4
2	2	2	3	3	4	4
3	1	2	1	2	4	3
4	1	1	2	2	3	3
5	1	2	1	2	4	4
6	3	2	2	1	3	4
7	2	2	3	3	3	4
8	3	2	3	3	4	4
9	2	2	2	3	4	4
10	3	3	1	2	3	4
11	1	2	2	3	4	4
12	3	2	3	3	4	4
13	2	2	2	3	4	4
14	3	2	2	2	3	4
15	2	2	2	2	4	4
16	2	2	3	2	4	4
17	2	2	2	2	3	4
18	2	2	3	3	4	4
19	1	2	2	2	4	4
20	3	3	3	3	4	4

Table 2: SCORES OF SMEAR LAYER REMOVAL AFTER LASER ACTIVATION OF FINAL IRRIGANT BY GUTTMAN RATING SYSTEM IN GROUP B (Laser agitation)

SAMPLE NO	CORONAL		MIDDLE		APICAL	
	Observer1	Observer2	Observer1	Observer2	Observer1	Observer2
1	2	2	3	3	3	4
2	2	2	3	3	3	4
3	2	2	2	2	2	3
4	1	1	3	2	1	3
5	2	2	3	2	4	4
6	1	2	2	1	3	4
7	2	2	3	2	2	4
8	1	1	3	2	4	4
9	2	2	3	3	2	3
10	2	2	2	2	2	2
11	2	2	3	3	3	3
12	2	2	4	4	2	2
13	2	2	2	2	2	2
14	2	2	3	4	3	4
15	2	2	2	3	2	2
16	2	2	4	4	3	4
17	1	1	2	3	2	3
18	2	2	2	3	2	2
19	2	2	3	3	3	3
20	2	2	3	3	4	4

Table 3: SCORES OF SMEAR LAYER REMOVAL AFTER ULTRASONIC ACTIVATION OF FINAL IRRIGANT BY GUTTMAN RATING SYSTEM IN GROUP C (Ultrasonic agitation)

SAMPLE NO	CORONAL		MIDDLE		APICAL	
	Observer1	Observer2	Observer1	Observer2	Observer1	Observer2
1	1	1	2	2	2	2
2	1	1	3	3	3	3
3	1	1	3	3	3	3
4	1	1	3	2	3	3
5	1	1	2	2	1	1
6	1	1	2	2	1	1
7	1	1	2	2	1	1
8	1	1	1	1	2	2
9	1	1	2	2	3	2
10	1	1	2	2	3	3
11	2	2	2	2	3	3
12	1	1	1	1	2	3
13	2	2	3	2	2	3
14	1	1	1	2	3	3
15	2	2	4	3	3	3
16	1	1	3	2	1	2
17	1	1	3	2	1	1
18	2	1	2	2	2	2
19	1	2	1	1	1	1
20	2	1	3	3	2	2

Table 4: MEAN SCORE OF SMEAR LAYER REMOVAL BY OBSERVER 1 AND OBSERVER 2 USING GUTTMAN RATING SYSTEM IN GROUP A (Manual dynamic agitation)

SAMPLE NO	CORONAL	MIDDLE	APICAL
	Mean score of observer 1 and 2	Mean score of observer 1 and 2	Mean score of observer 1 and 2
1	1.5	2.5	4
2	2	3	4
3	1.5	1.5	3.5
4	1	2	3
5	1.5	1.5	4
6	2.5	1.5	3.5
7	2	3	3.5
8	2.5	3	4
9	2	2.5	4
10	3	1.5	3.5
11	1.5	2.5	4
12	2.5	3	4
13	2	2.5	4
14	2.5	2	3.5
15	2	2	4
16	2	2.5	4
17	2	2	3.5
18	2	3	4
19	1.5	2	4
20	3	3	4

Table 5: MEAN SCORE OF SMEAR LAYER REMOVAL BY OBSERVER 1 AND OBSERVER 2 USING GUTTMAN RATING SYSTEM IN GROUP B (Laser agitation)

SAMPLE NO	CORONAL	MIDDLE	APICAL
	Mean score of observer 1 and 2	Mean score of observer 1 and 2	Mean score of observer 1 and 2
1	2	3	3.5
2	2	3	3.5
3	2	2	2.5
4	1	2.5	2
5	2	2.5	4
6	1.5	1.5	3.5
7	2	2.5	3
8	1	2.5	4
9	2	3	2.5
10	2	2	2
11	2	3	3
12	2	4	2
13	2	2	2
14	2	3.5	3.5
15	2	2.5	2
16	2	4	3.5
17	1	2.5	2.5
18	2	2.5	2
19	2	3	3
20	2	3	4

Table 6: MEAN SCORE OF SMEAR LAYER REMOVAL BY OBSERVER 1 AND OBSERVER 2 USING GUTTMAN RATING SYSTEM IN GROUP C (Ultrasonic agitation)

SAMPLE NO	CORONAL	MIDDLE	APICAL
	Mean score of observer 1 and 2	Mean score of observer 1 and 2	Mean score of observer 1 and 2
1	1	2	2
2	1	3	3
3	1	3	3
4	1	2.5	3
5	1	2	1
6	1	2	1
7	1	2	1
8	1	1	2
9	1	2	2.5
10	1	2	3
11	2	2	3
12	1	1	2.5
13	2	2.5	2.5
14	1	1.5	3
15	2	3.5	3
16	1	2.5	1.5
17	1	2.5	1
18	1.5	2	2
19	1.5	1	1
20	1.5	3	2

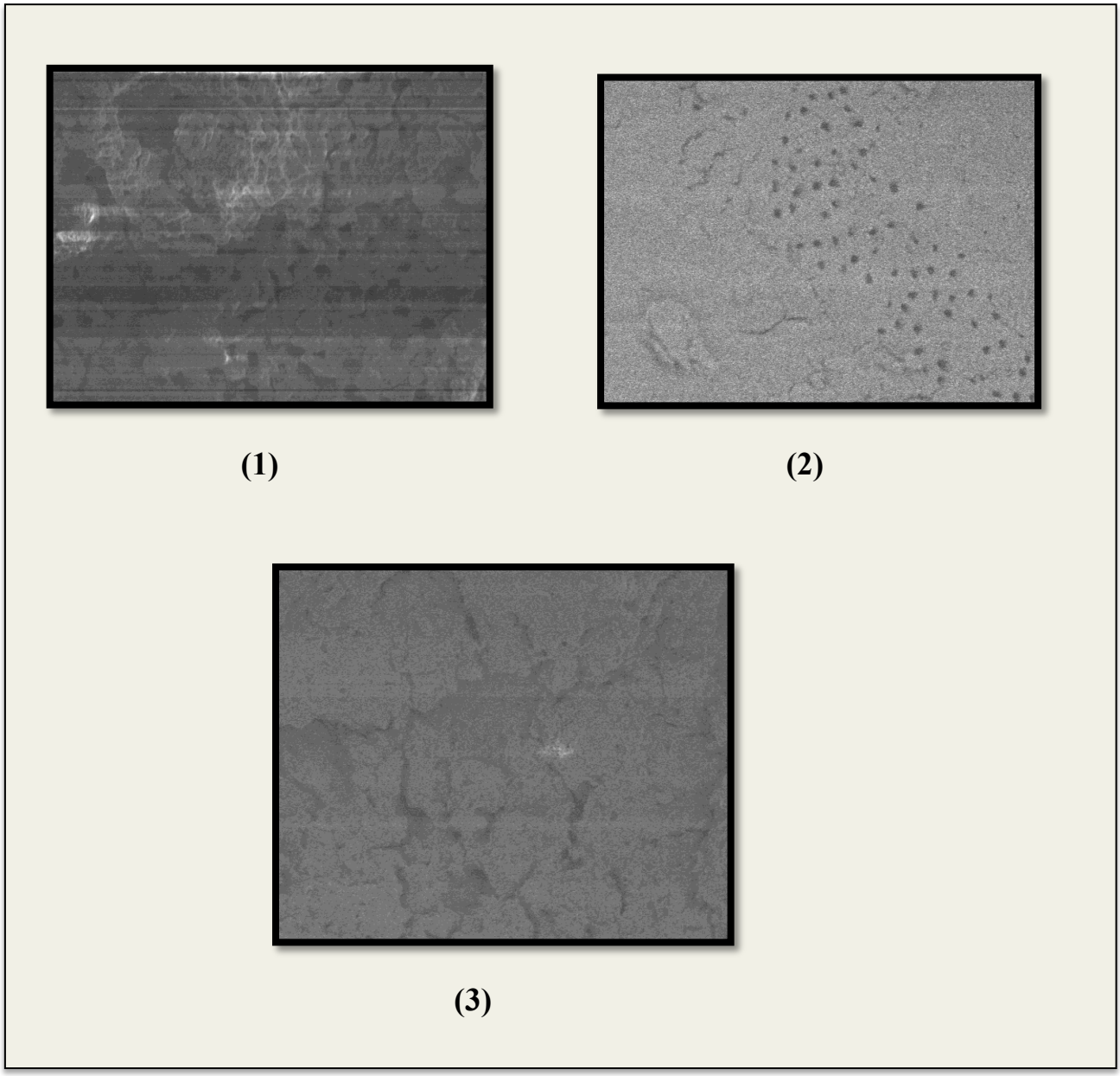


Figure 10: (1) showing coronal third of group A, (2) showing middle third of group A, (3) showing apical third of group A (Manual agitation group) at 1000x magnification

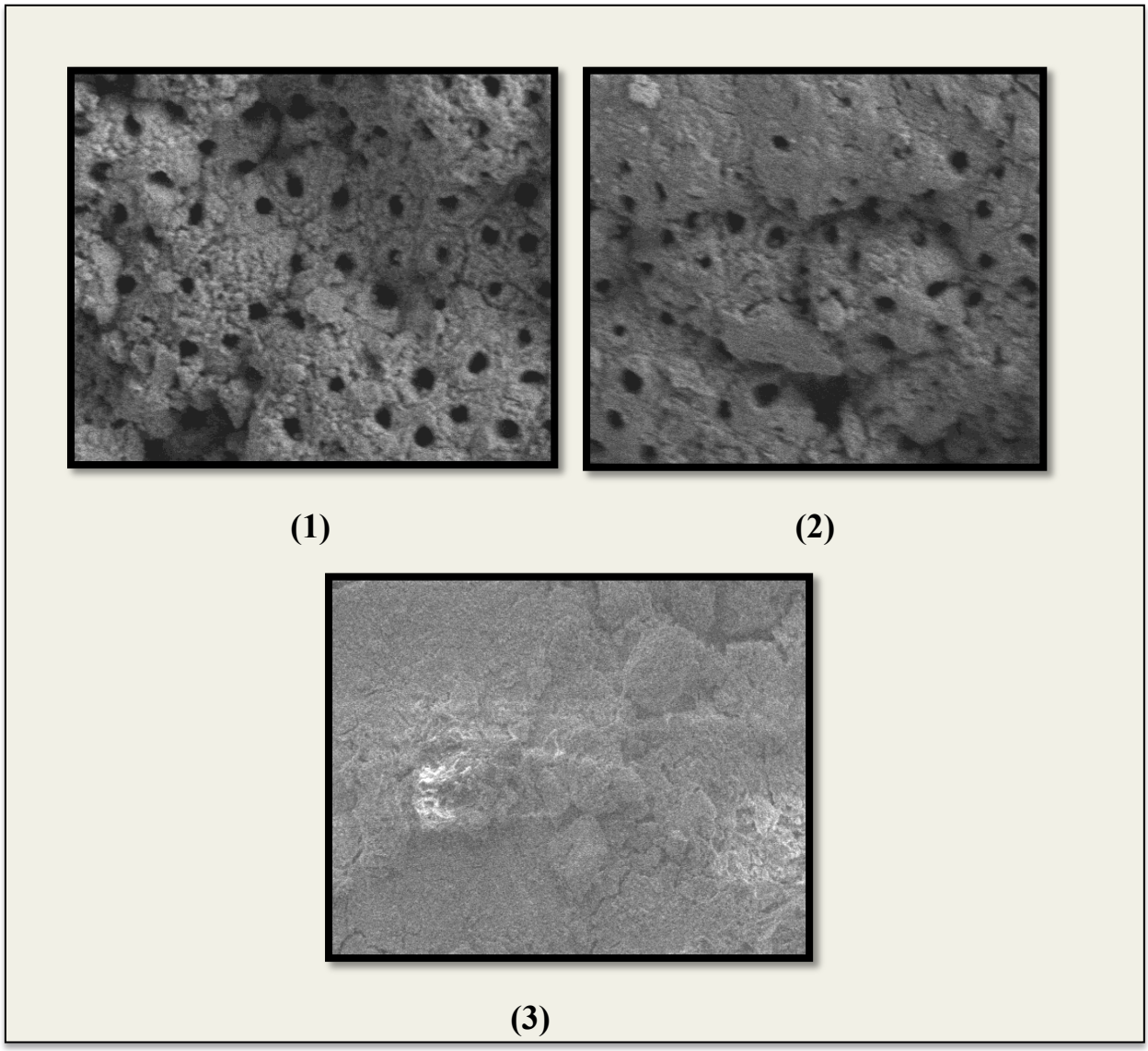


Figure 11: (1) showing coronal third of group B, (2) showing middle third of group B, (3) showing apical third of group B (Laser group) at 1000x magnification

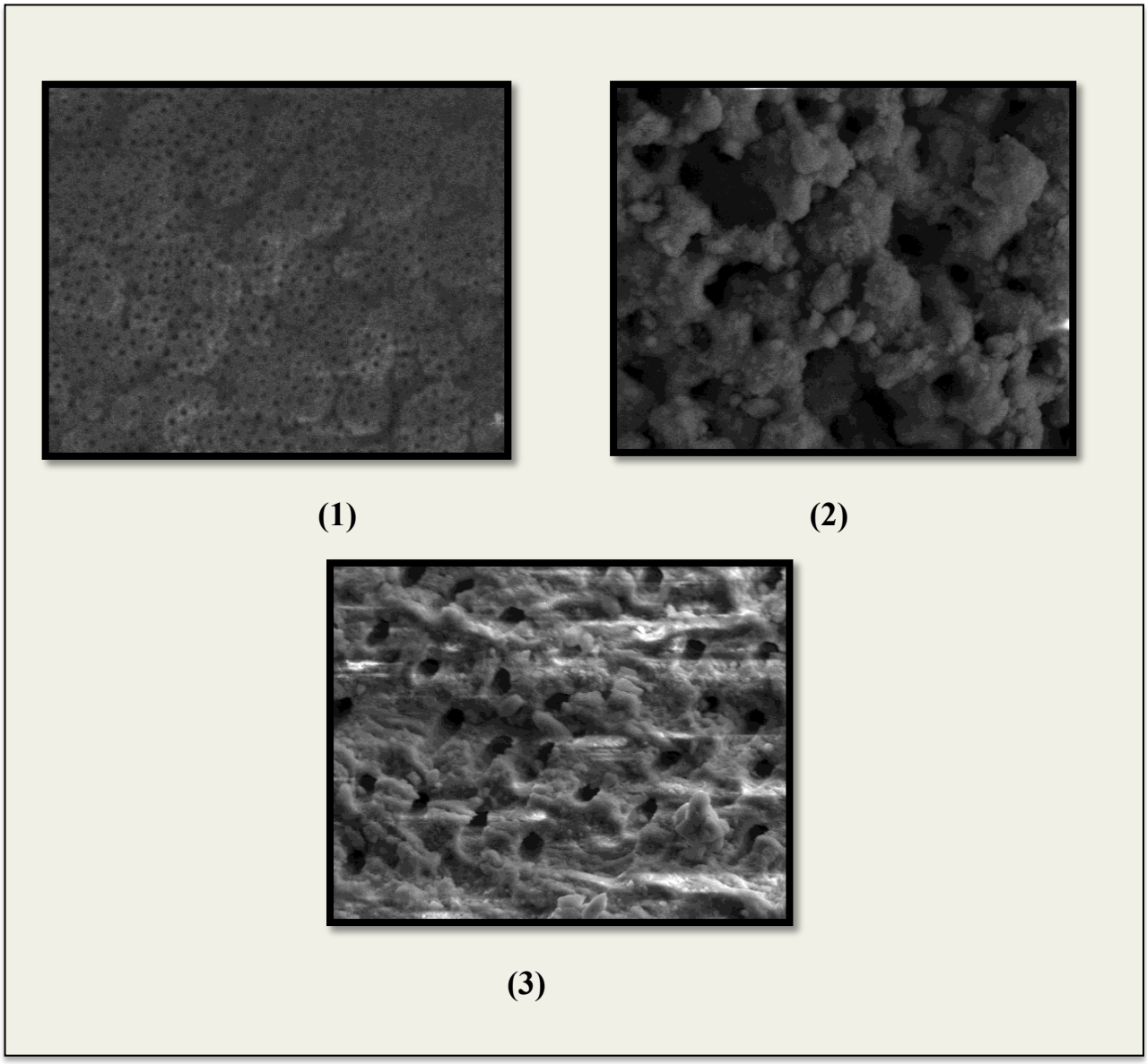


Figure 12: (1) showing coronal third of group C, (2) showing middle third of group C, (3) showing apical third of group C (Ultrasonic group) at 1000x magnification

Figure 13: Showing scoring criteria for Guttmann score 1 at 1000x magnification

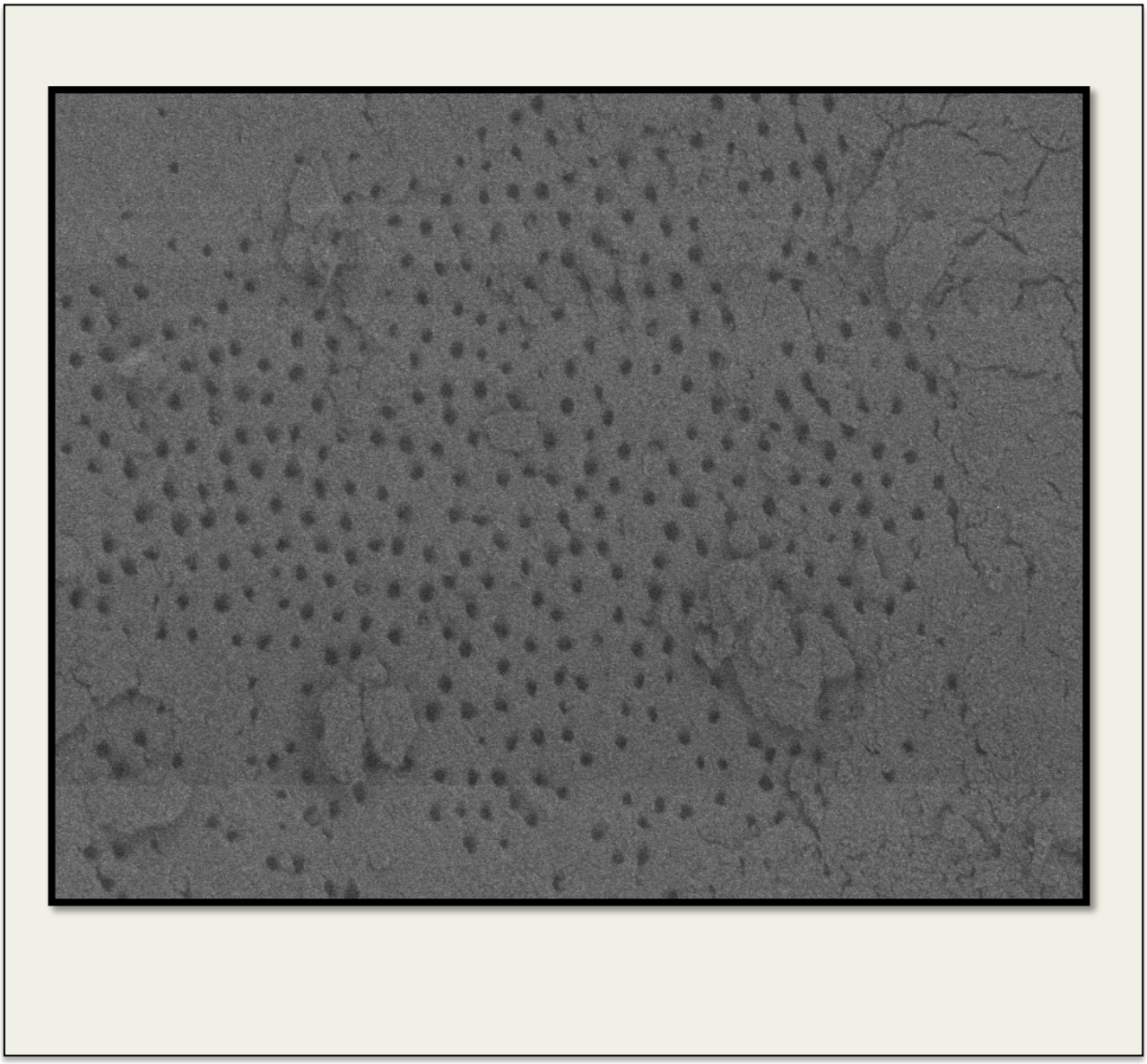


Figure 14: Showing scoring criteria for Guttmann score 2 at 1000x magnification

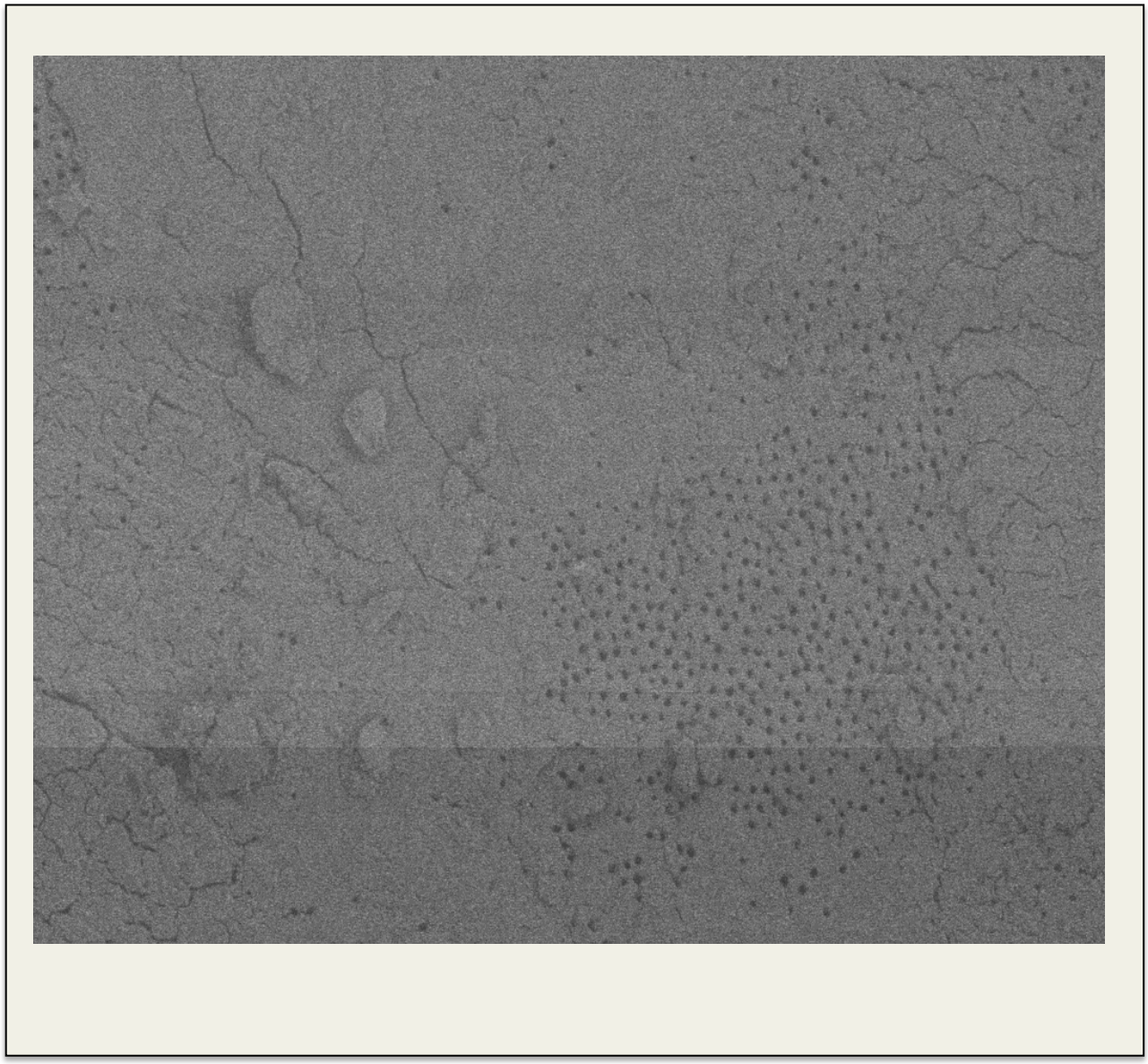


Figure 15: Showing scoring criteria for Guttmann score 3 at 1000x magnification

Figure 16: Showing scoring criteria for Guttmann score 4 at 1000x magnification

STATISTICAL ANALYSIS

The collected data was subjected to statistical analysis using SPSS version 17. The data was assessed for normality by Shapiro-Wilks test. Based on the distribution of data, the appropriate statistical test was used. Descriptive statistics were obtained for each group. The mean smear layer removal between three groups were compared using non parametric Kruskal Wallis test and subsequently with Mann-Whitney U Test for comparison within the groups. The significance level for all statistical analysis was set at $\alpha=0.05$

Table 7: Descriptive statistics of mean scores ± standard deviation comparing the remaining smear layer scores in the apical, middle and coronal third among the three final irrigant activation techniques.

	N*	Mean	Std.Deviation	Minimum	Maximum
Coronal	60	1.692	.54	1	3
Middle	60	2.40	.66	1	4
Apical	60	2.95	.94	1	4

* N=Total number of specimens

Table 8: Mean smear layer remaining scores at coronal, middle and apical third between three groups were done using Kruskal Wallis test.

	Groups	N*	Mean Rank	P value
Coronal	Manual activation	20	39.88	0.001
	Laser	20	35.38	
	Ultrasonic	20	16.25	
Middle	Manual activation	20	32.75	0.034
	Laser	20	38.20	
	Ultrasonic	20	24.55	
Apical	Manual activation	20	47.22	0.001
	Laser	20	28.20	
	Ultrasonic	20	16.08	

* N= Number of specimens in each group

INTERGROUP COMPARISON OF GROUP A, B AND C

Kruskal wallis test analysis was done to evaluate the non parametric mean scores to find the smear layer removal between three groups .The results of the present study at coronal third, showed Group C (ultrasonic), had least mean rank score followed by group B (laser) and group A (manual), with high statistical significance of 0.001,which means there was a significant difference between the coronal third scores of each group. Ultrasonics showed better efficacy in smear removal at coronal third followed by laser.

At the Middle third, Group C (ultrasonic), had least mean rank score followed by group A (manual) and group B (laser), with a statistical significance of 0.034, which showed significant difference in middle third of each groups. The ultrasonic group showed better efficacy in smear layer removal followed by manual agitation.

At the apical third, Group C (ultrasonic), had least mean rank score followed by Group B (laser) and Group A (Manual), with high statistical significance of 0.001,which showed significant difference in apical third of each groups. The Ultrasonic group showed better efficacy in smear layer removal than manual agitation.

Table 9: Statistical significance in coronal third among three groups of remaining smear layer scores using Mann-Whitney test.

CORONAL	Manual	Laser	Ultrasonic
Manual	-	0.355	0.001
Laser	0.355	-	0.001
Ultrasonic	0.001	0.001	-

CORONAL THIRD

At the coronal third, Group C (ultrasonic), showed a statistically significant difference in smear layer removal when compared to Group B (laser) and Group A (manual). Group B (laser) showed statistically insignificant difference in smear layer removal when compared to Group A (Manual), which means there was no much difference in smear layer removal between manual and laser group

Table 10: Statistical significance in middle third among three groups of remaining smear layer scores using Mann-Whitney test.

MIDDLE	Manual	Laser	Ultrasonic
Manual	-	0.086	0.045
Laser	0.086	-	0.014
Ultrasonic	0.045	0.014	-

MIDDLE THIRD

At the middle third, Group C (ultrasonic), showed significant difference when compared to Group B (laser) and Group A (manual). Group B (laser) showed less significant difference when compared to Group A (manual).

Table 11: Statistical significance in apical third among three groups of remaining smear layer scores using Mann-Whitney test.

APICAL	Manual	Laser	Ultrasonic
Manual	-	0.001	0.001
Laser	0.001	-	0.001
Ultrasonic	0.001	0.001	-

APICAL THIRD

At the Apical third Group C (ultrasonic) was highly significant when compared to Group B (laser) and Group A (manual). Group B was also highly significant when compared to Group A.

Table 12: Descriptive statistics of mean scores ± standard deviation comparing the remaining smear layer scores among the three final irrigant activation techniques at different levels.

	N*	Mean	Std.Deviation	Minimum	Maximum
Manual	60	2.69	.905	1	4
Laser	60	2.48	.765	1	4
Ultrasonic	60	1.84	.778	1	4

*N=Total number of specimens

Table 13: Mean smear layer remaining scores between three groups were done using Kruskal wallis test.

	Groups	N*	Mean Rank	P value
Manual	Coronal	20	17.65	0.001
	Middle	20	23.55	
	Apical	20	49.79	
Laser	Coronal	20	14.92	0.001
	Middle	20	37.28	
	Apical	20	39.30	
Ultrasonic	Coronal	20	17.05	0.001
	Middle	20	30.35	
	Apical	20	33.10	

*N = Number of specimens in each group

INTRAGROUP COMPARISON

Kruskal Wallis test analysis was done to evaluate the non-parametric mean scores to find the smear layer removal with in three groups.

IN MANUAL GROUP (GROUP A)

According to the results of this present study, coronal third showed highest smear layer removal followed by middle third and apical third. Apical third had least value of smear layer removal. There was a high statistical difference of smear layer removal at different depths. Manual agitation removed more smear layer at coronal than middle third and apical third.

IN LASER GROUP (GROUP B)

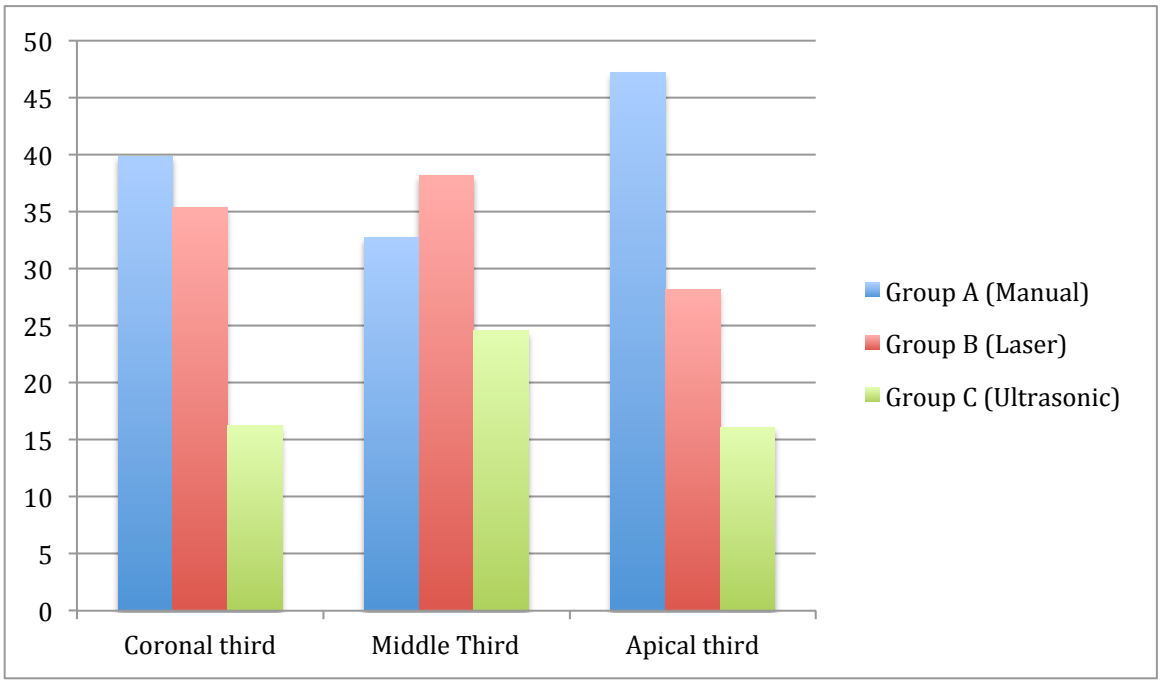
Coronal third showed highest smear layer removal followed by middle third and apical third. Apical third had least value of smear layer removal. There was a high statistical difference of smear layer removal at different depths. Laser agitation removed more smear layer at coronal than middle third and apical third, while smear layer removal at middle and apical third was statistically in significant.

IN ULTRASONIC GROUP (GROUP C)

Coronal third showed highest smear layer removal followed by middle third and apical third. Apical third had least smear layer removal. There was a high statistical difference of smear layer removal at different depths. Ultrasonic agitation removed more smear layer at the coronal third than middle third and apical third, while smear layer removal at middle and apical third was statistically insignificant.

SUMMATIVE CONCLUSION

According to the statistical analysis ultrasonic group showed better efficacy in removal of smear layer at the coronal, middle and apical thirds, when compared to laser group and manual group. Laser group removed more smear layer in coronal third than middle and apical third, while manual agitation showed less smear layer removal efficacy in apical, middle and coronal third when compared to other two groups.



Graph 1: Showing smear layer removal score Between Group A, Group B, Group C at Coronal third, middle third and apical third.

Discussion

DISCUSSION:

Chemo mechanical phase of endodontic treatment is designed to remove debris and infected material from the root canal and to shape the canal. Irrigation is a crucial step in , during and after instrumentation for effective removal of smear layer. In infected root canals smear layer produced by instrumentation should be removed, because bacteria invade the dentinal tubules and accessory canals. The smear plugs produced affect the efficacy of intracanal medicaments there by preventing periapical healing. So irrigation should be done for thorough cleansing of canals and disinfection of canals.[43]

Passive irrigation is done by slow dispensing of irrigant of choice with different gauge needles. In order to remove the smear , the needle should be loose in the canal. Passive irrigation limits the irrigant penetration, circulation and cleansing. Active irrigation initiates dynamics and flow within the fluid and thus improves cleansing .In well shaped canals fluid activation has a critical role in cleaning the canals by facilitating fluid penetration through all aspects of root canal system. [44]

The quality of smear layer removal will vary with the type of solvents used. The solvents remove organic or inorganic components of smear layer. Their action will be enhanced when acting in combination with activation techniques. Sodium hypochlorite is a normal organic solvent , the accepted irrigant in endodontics, but it cannot remove the inorganic part of the smear layer by itself. It must be used along with chelating agent to be effective for combined efficacy. Irrigant activation methods like ultrasonic and laser agitation

have been used to remove the smear layer .None of the current irrigants ,irrigant activation techniques and devices showed complete removal of the smear layer.[45]

The purpose of this study was to evaluate the effectiveness of smear layer removal after manual activation ,laser activation and ultrasonic activation of the final irrigant. Smear layer removal was evaluated using scanning electron microscope at different levels i.e. coronal ,middle and apical third ,each section being 3mm,6mm and 9mm from the apex.

Sodium hypochlorite was the most widely used irrigant which dissociates into Na + and hypochlorite ion (OCl-) , when combined with water. Hypochlorous acid has antibacterial efficacy and helps in the removal of the organic portion of the smear layer. It is used in different concentrations from 0.5 to 7 %.[41].In this study 5% NaOCl and 17% EDTA were used . EDTA (17% disodium salt ,pH 7) is an effective chelating agent which aids in the removal of the smear layer .

Group A (Manual activation) showed heavy aggregates of smear layer through out the sample which shows that manual dynamic agitation, is ineffective in removing smear layer. Coronal and Middle thirds of all specimens in group A showed better removal of smear layer than apical third and had statastically significant difference. It is in agreement with the results of studies conducted previously [44,45].The coronal and middle third of the root canal had more canal diameter when compared to the apical third ,allowing better flow of

the irrigants into the tubules and cleansing the canals, thus improving the efficacy of smear layer removal in coronal and middle thirds[47].

In group B (Laser group), 970 nm laser using 7 Watts power was used in pulsed mode based on the study done by Alfredo et al [48] who reported that these parameters increase the temperature by 10°C,which is acceptable for the supporting periapical tissues.[47]The diode laser was able to remove smear layer by melting, but the canals were obliterated with smear plugs. Increase in the temperature evaporates the final irrigants there by charing the root canals. The apical third in group B had greater smear layer scores when compared with middle and coronal third which had a statastically significant difference. The coronal and apical third respectively had a statistically significant difference. This is because the canal in the apical region is constricted, which can cause the close approximation of laser tip to the root canal walls and thus melting and evaporating the smear layer easily .[49]

Constricted dentinal tubule openings , localized fusion and melting of dentinal tubules were found in apical third of all the laser samples. This result was against the study reported by Wang et al[50] who reported cleaner and open dentinal tubules in root canals. This difference was due to the laser setting used in the treatment and also the irrigants used in their study.

When ultrasonics were used as an adjuvant to the NaOCl it increased the efficacy of smear layer removal of NaOCl by enhancing its penetration into the

narrow canals in the apical region of root canals. Ultrasound is a vibration or acoustic wave with a frequency higher than that detected by the human ear .Ultra sonic tips have advantage over hand and rotary instruments because they do not rotate .

There are two basic methods for producing ultrasonic wave magnetostriction and peizo electric principle. Magnetostriction converts the electromagnetic energy into mechanical energy while peizoelectric principle uses a crystal which changes in size by applying electrical charge. [(51)] Therefore with out producing heat ,the crystal undergoes mechanical oscillation.The other advantage is it moves in a linear path from back to front which is ideal for endodontic treatment.During this process the energy is transmitted to the file or smooth oscillating wire to the irrigant by means of ultrasonic waves and creates acoustic streaming and cavitation with in the irrigant solution. [(52)].Acoustic streaming is maximised when tips of smaller instruments vibrate freely in the irrigant.Lumely et al reported the use of only 15 # endosonic files for maximising the microstreaming effect and efficient cleansing of canals.

In Group C (ultrasonic),smear layer was removed from the root canals at the apical, middle and coronal thirds. It had least smear layer scores in apical and coronal third when compared to middle third .This can be due to the ultrasonic tips which does not propagate waves efficiently at the middle third.

Due to acoustic streaming, there was more intensity in magnitude and greater velocity of the waves at apical and coronal segments of the endosonic file .This was the same as reported by Cameron et al[(27)] .It was not same as the study results given by Huque et al [(53)] who reported that passive

ultrasonic irrigation does not remove smear layer. This difference might be due to the irrigants and ultrasonic settings used in the study .

Scanning electron microscope was used to analyse the images at 1000 x magnification.The photographs were evaluated by two observers at the coronal ,middle and apical third of the anterior teeth based on Guttman scoring criteria[46] as used in the study done by K Amin et al.

Statistical analysis with Kruskal wallis test and subsequent Mann Whitney test was done. There was a significant difference at coronal ,middle and apical third of each group.

Within the limitations of the study none of the groups showed complete removal of smear layer. The ultrasonics showed better efficacy in smear removal at coronal, middle and apical third followed by laser and manual agitation.

Summary

SUMMARY

The success of endodontic therapy depends on smear free canals .The scrupulous sealing of dentinal tubules can be accomplished by eradicating bacteria.This may be of immense concern as the bacteria , if remaining in the dentinal tubules of root canals can cause reinfection of the root canal system.So the present study aimed at removing smear layer from the dentinal tubules by final irrigant activation using Manual,diode laser and ultrasonic techniques.A total of 60 specimens were divided into 3 groups A,B and C. 20 specimens in group A were activated by manual agitation technique.20 specimens in group B were activated by diode laser and 20 specimens in group C were activated by ultrasonics.Treated samples were analysed at 1000x using Scanning electron microscope. SEM photographs were analysed and were scored by two observers using Guttmans scoring criteria. Stastical analysis was done using Kruskal Wallis test and Mann whitney test.

The findings of the present study can be summarized as follows.

1. None of the groups showed complete removal of the smear layer.Ultrasonic activation of specimens efficiently removes smear layer at apical (3mm) , middle (6mm) and coronal(9mm) thirds when compared to laser activated and manual agitated group.
2. Laser evaporates and melts the dentinal tubules .This will effect the sealer penetration.
3. Manual dynamic agitation shows poor efficiency in removal of smear layer when compared to the laser and ultrasonic group.

Conclusion

CONCLUSION

With in the limitations of the present study , smear layer removal varied with different irrigant activation techniques.The mode of irrigant activation, has a significant influence on the removal of the smear layer.Ultrasonic activation efficiently removes the smear layer after 2 minutes of activation where as laser activation melts the dentin,which can effect the final hermatic seal.Ultrasonic activation of the final irrigant provides efficient smear layer removal when compared to laser and manual activation .

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Annexure

INSTITUTIONAL ETHICAL COMMITTEE

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Ref.: 079 /KSRIDSR/EC/2014 **Date : 26.11.2014**

To

Dr.C.P.Sreedev,
Postgraduate Student,
Dept. of Oral Medicine & Radiology,
KSR Institute of Dental Science & Research,

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Your dissertational study titled "COMPARATIVE EVALUATION OF PUSH OUT BOND STRENGTH AND APICAL SEALING ABILITY OF THREE DIFFERENT ROOT CANAL SEALERS – AN INVITRO STUDY" presented before the ethical committee on 24th Nov.2014 has been discussed by the committee members and has been approved.

You are requested to adhere to the ICMR guidelines on Biomedical Research and follow good clinical practice. You are requested to inform the progress of work from time to time and submit a final report on the completion of study.

Signature of Member Secretary
(Dr.G.S.Kumar)

APPENDIX: 1 Guttmann rating system for remaining smear layer scores. (46)

Score	Criteria
1	Little or no smear layer; covering<25%of the specimen; most tubules were visible and patent, or almost complete laser melting
2	Little to moderate or patchy mounts of smear layer; covering 25-50% of the specimen; many tubules visible and patent, or laser melting
3	Moderate amounts of scattered or aggregated smear layer; covering 50-75% of the specimen; minimal to no tubule visibility or patency, or scattered laser melting
4	Heavy smear layer covering >75 % of the specimen; no tubule orifices were visible or patent; or no visible laser melting